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(54) Radio telephone system

(57) In communications apparatus, particularly cordless telephone sets, there is a need to maximise the number of communication links that can be made from a given area or volume. This is achieved by reducing the transmit power of a transceiver Y below its maximum in response to a signal level 50 of existing users V on that channel, as measured by the transceiver Y that is setting up a call. In particular, the reduction in transmit power p' is dependent on (e.g. equal to) the amount p by which the power of existing users exceeds a predetermined lower threshold T_L

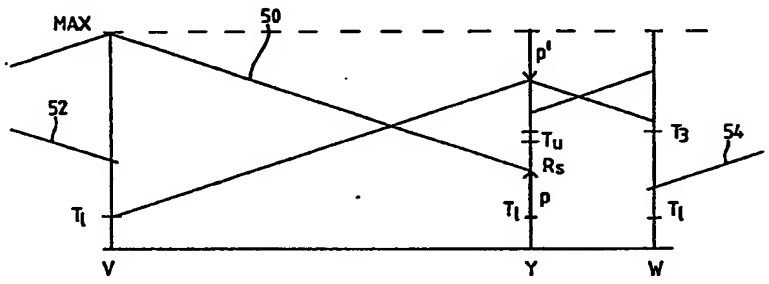

FIG.3.

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The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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1/4

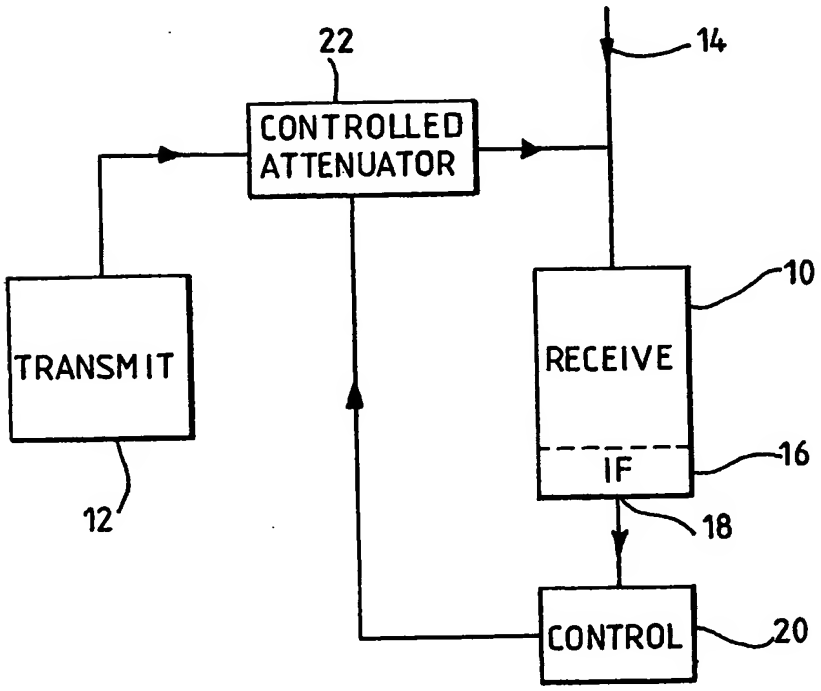

FIG.1.

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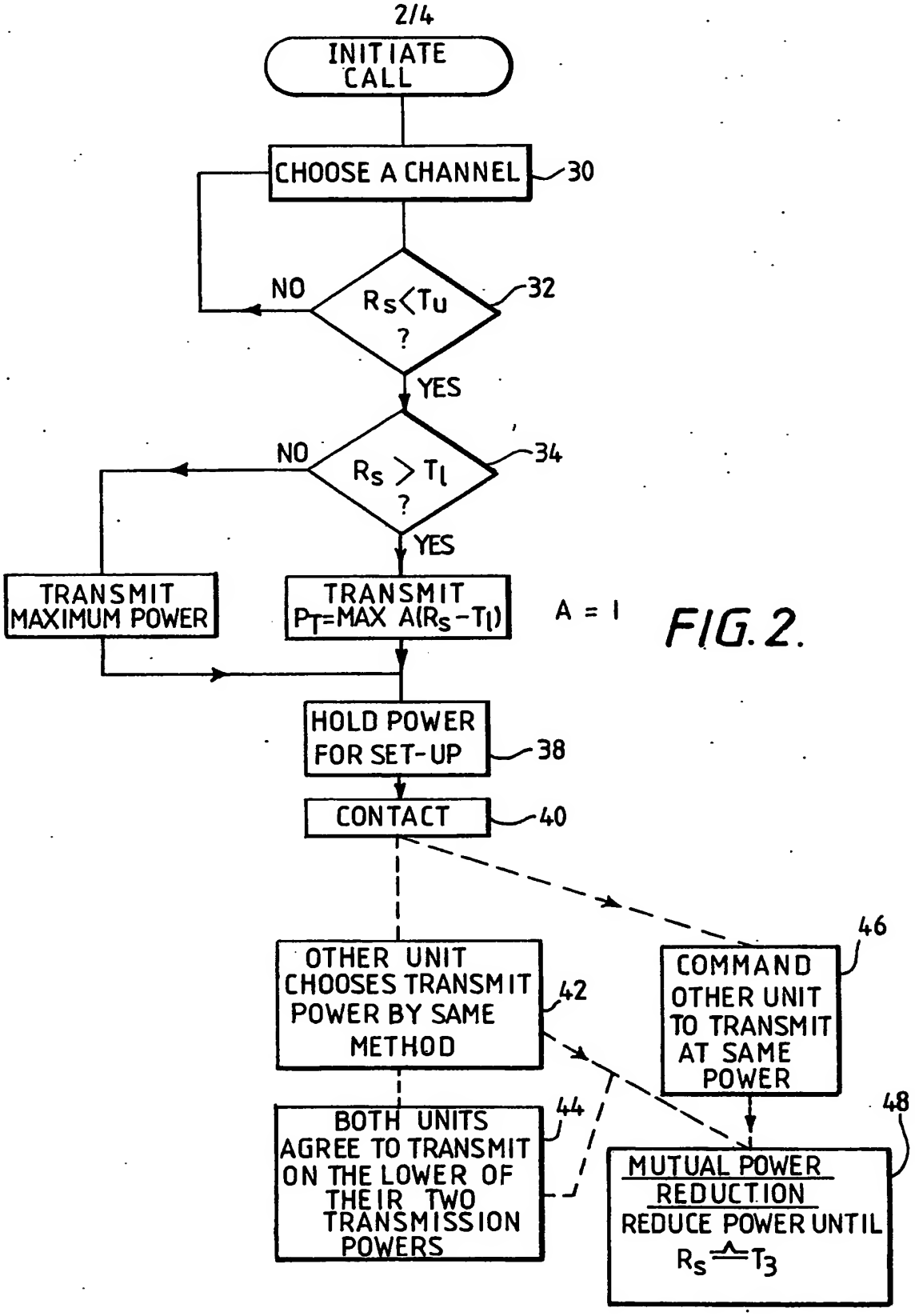

FIG. 2.

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3/4

FIG.3.

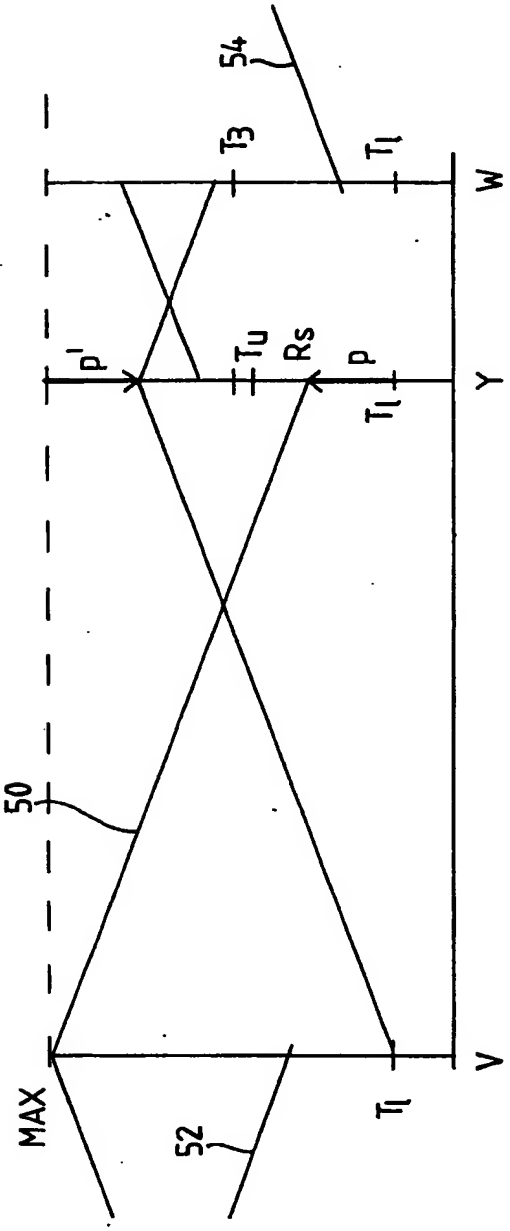
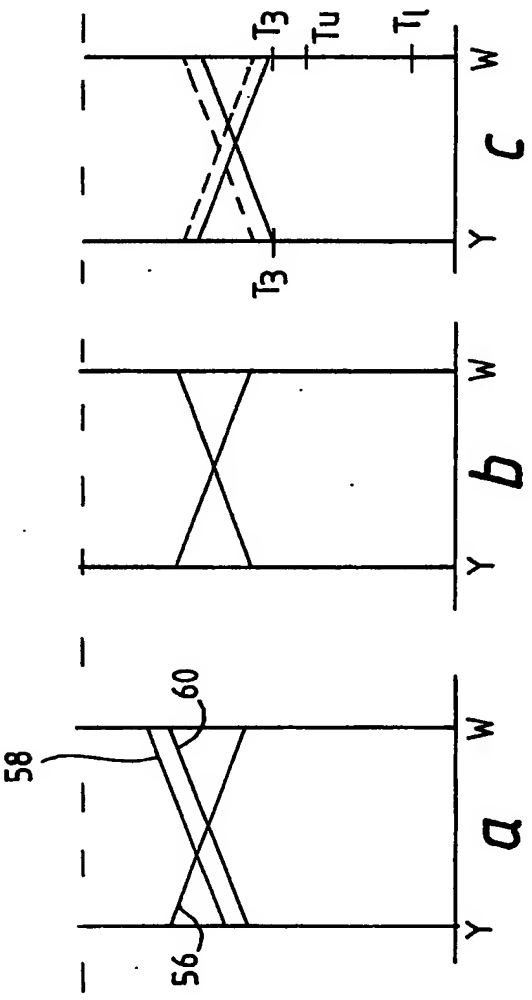


FIG.4.



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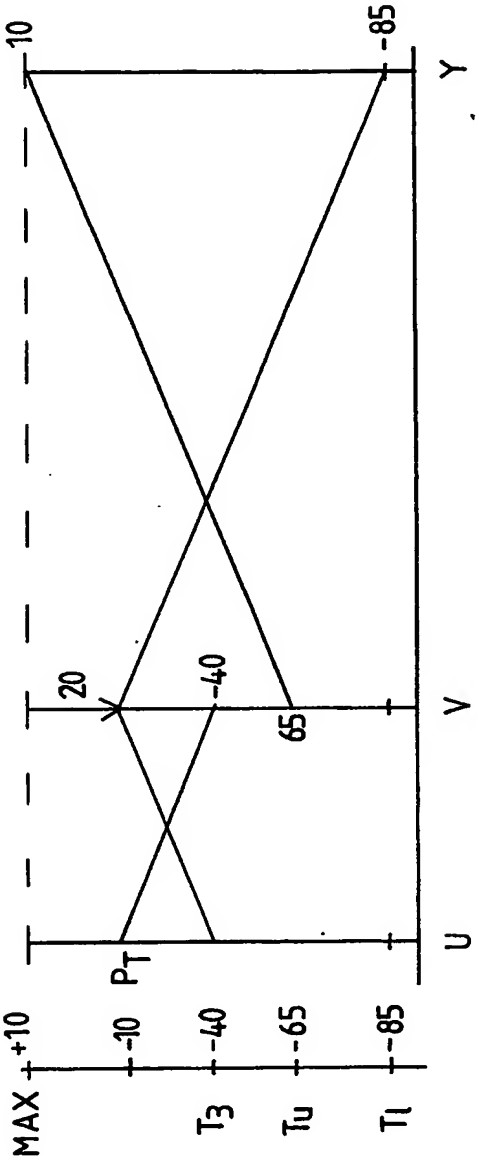

FIG.5.

SPECIFICATION

Communications apparatus and method

This invention relates to a communications apparatus and method, particularly to "cordless telephone sets" and more particularly to a method and apparatus for enabling many such telephone sets to operate on a particular channel within a given area or volume.

Generally, a cordless telephone set is a telephone terminal connected to an exchange line or an extension line and is integrated with or accompanied by a normal telephone set. It consists of two parts which are connected by a radio link, namely a fixed device (the base unit) and a portable device (the "handset") permitting the same basic functions as a normal telephone within a limited area around the fixed part.

A cordless telephone set may be either:-

a) a fully functional apparatus on which calls can be set up and answered by the portable device, or

b) a limited apparatus where the portable device has no facility for initiating outgoing calls.

Prior art types of cordless telephone sets normally have their base units connected to an exchange line, connecting to the Public Switched Telephone Network (PSTN). However, the present invention is not limited to such types, and includes portable and/or mobile base units, which can communicate by radio with a radio network, such as a cellular system, and if desired have a facility for connection to the PSTN.

With the predicted growth of the use of cordless telephone sets and cellular radio, particularly in commercial application, there is a need to maximise the number of communication links that can be made from a given area or volume using a given number of channels, i.e. to increase the user density. Several systems exist at present giving reasonable density and good flexibility in the range within which a handset can operate from a base unit.

An example of an existing system operates on the principle of searching for the channel on which existing signals are weakest and setting up communication at full power on that channel. This is a very aggressive arrangement which means that a call will be set up irrespective of the interference it might cause to existing links on that channel. As more such telephone sets are used and especially as it becomes desirable to communicate data other than speech by cordless links, so will these systems find their limitations.

An alternative arrangement has been proposed in our co-pending U.K Patent Application No. 8509782 in which units in operation control their transmission power and increase power, when possible, if another unit attempts to establish communication, on the same channel, which will cause corruption of the already established link. Such reaction in response to incoming units could lead to a chain reaction of units increasing power in certain circumstances of dense use.

It is therefore desirable to increase the use of each channel separately without necessarily reducing the range of operation of handsets, and to avoid problems associated with prior art arrangements.

It is envisaged that by increasing user density, it will be possible for internal or private switchboards, e.g. in offices and factories, which require vast lengths of wiring to be installed to each individual telephone instrument from the switchboard, to be replaced by a communications system according to the present invention, wherein each user has a portable handset, the switchboard is replaced by a base unit connected to the PSTN, and further base units (which may be portable) - or sub-base units - are optionally provided in various other locations in the building, depending on its size. Such a communications system is the subject of our co-pending U.S. Patent Application Nos: 8428159; 8424308 and 8500452.

According to the present invention, we provide a communications device comprising a radio receiver and a radio transmitter and means for automatically reducing the transmit power below maximum in response to the received signal level of existing users of a communications channel so as to reduce the likelihood of interference to the existing users.

The device may be a handset or a base unit of a cordless telephone.

Preferably, the device further comprises means for reducing the transmit power by an amount dependent on the amount by which the said received signal level exceeds a predetermined lower threshold and means for comparing the said received signal level with a higher threshold and inhibiting communication if the said signal level exceeds the higher threshold. The device searches through radio channels, measuring the signal strength of existing users on the channels and selects the channel on which the said signal strength is least, before commencing transmission on that channel. The transmit power reduction is made in incremental steps.

Preferably, the communications device (the first device) communicates with a second such device and has means for transmitting to the second device an encoded command for controlling the transmit power of said second device and means for receiving and decoding an encoded command from the said second device for controlling the transmit power of the first device. Means may be provided for adopting a transmit power which is the lower of the two transmit powers of the first and second devices. Means may also be provided for commanding the second device to reduce power until the signal received from that second device falls below a predetermined field strength as received by the first device and for scanning the communications channels when waiting for a communication link to be initiated, measuring the field strengths on those channels, storing those field strengths and adopting a transmit power which is dependent on a field strength at an earlier instant as stored.

According to the broadest aspect of the invention, a method of occupying a channel in an inter-active communication device is provided, comprising the steps of measuring the radiation strength on that channel and occupying the channel at a transmit power which is reduced from maximum by an amount dependent on the measured radiation strength.

A preferred embodiment of the invention is now described by way of example with reference to the accompanying drawings, in which:-

Figure 1 is a block diagram of an implementation of a unit for use in the invention;

Figure 2 is a flow diagram for use in explaining the invention;

Figure 3 is a schematic field strength diagram of units operating according to the invention;

Figure 4 shows three schematic field strength diagrams of two units operating according to further aspects of the invention, and

Figure 5 is a schematic field strength diagram of units operating according to the invention with typical numerical field strength given by way of example.

Referring to Figure 1, a cordless telephone unit is shown which can be either a handset or a base unit. The unit comprises a receiver 10, a transmitter 12 and an aerial 14 as are commonly known in the art. The receiver 10 further comprises an intermediate frequency amplifier 16 capable of measuring the received signal strength and providing a Receive Signal Strength Indicator output (RSSI) 18 which is fed to control circuitry 20 which controls an alternator 22. The control circuitry 20 is arranged to accomplish a test routine as is described below with reference to Figure 2. The alternator 22 alternates the transmission signal being fed to the aerial 14.

Referring now to Figure 2, the routine for testing the signal strength is shown in flow diagram form in which the symbols have their meanings as follows:-

Rs is the received signal strength on a given channel; Tu is an upper field strength threshold;

T_L is a lower field strength threshold which may be at a level at which background noise causes crackling in a received signal;

P_T is the selected transmission field strength;

Max is the field strength associated with maximum transmission power;

A is a factor chosen as a design parameter but may in the first instance be chosen as equal to 1, and

T_3 is a third threshold, greater than Tu, and comprises a received signal strength corresponding to a minimum allowable operating transmit power.

For simplicity, power diminution has been represented by straight lines rather than more accurate inverse square law relations but this should not detract from the explanation.

The unit which wishes to initiate a call scans through the channel with its receiver and chooses the channel on which the field strength (created by other users) is lowest (box 30). This is compared (box 32) with Tu and, if less than Tu, then it is compared (box 34) with T_L. Three possibilities exist, for which the outcomes are as follows:

(a) $Rs > Tu$ - in this case the field strength on even the weakest channel is too high because there is another user nearby so the channel cannot be used. The user must wait for a channel to become available.

(b) $Rs < T_L$ - there is no significant signal on the channel so the user can transmit at full power.

(c) $T_L < Rs < Tu$ - the unit cannot be permitted to transmit at full power, otherwise it would interfere with another user already established on the channel, but it can transmit at a reduced power and the amount the power is reduced by should be equal to the amount by which Rs exceeds T_L. This is further explained below with reference to Figure 3. This now gives $P_T = Max - (Rs - T_L)$.

Having selected the transmission power, that power is maintained (box 38) during set up of the call and contact is made (box 40) by methods standard in the art. Thereafter, there are a number of possibilities for power selection. Either (box 42) the unit with which a call is being established chooses a transmit power by the same criteria and this power will be dependent on units close to that unit, or (box 46) the unit may simply command the other unit to adopt the same transmit power. In the case of box 42 when the transmit powers are different, the units may optionally exchange commands to select the lower of their two transmit powers (box 44). In any case, mutual power reduction may be employed, reducing power until the received signal strengths fall below a third threshold T_3 (box 48).

Figure 3 indicates the reason for the size of the power reduction. V is a unit which is in operation, transmitting at full power Max (line 50), in communication with another unit not shown. Y is yet another unit, unrelated to V, which wishes to set up a call with unit W. Unit Y measures the field strength of the signal from V on the channel in question and finds that it exceeds T_L by an amount p. If Y were to begin transmitting at full power Max then, by reciprocity, it would result in a field strength at V of $T_L + p$. This would be encroaching on the signal 52 from the unit communicating with V and would be undesirable. If, however, Y transmits at a power Max-p', where p'=p, then the resulting signal strength at V would be T_L and this would be acceptable. For this reason p' is chosen as $Rs-T_L$. Y and W can now set up a call, and the selected power of W may depend on another signal 54 in the same way.

p and p' need not be equal but instead a multiplication factor A may be chosen such that $p' = Ap$. $A < 1$ will give a more aggressive system giving greater range for the incoming call but possibly detrimental to the existing call while $A > 1$ will give a kinder system, protective to existing calls.

In practice, the power reduction may be made in, say, two steps to the nearest whole step.

The alternative possible arrangements at this stage are shown in Figures 4a, b and c. In Figure 4a, each unit has a different transmit power 56 and 58 but the higher of the two is reduced down to the lower level 60. This avoids unnecessary power transmission and unnecessary crowding of the available channels. It is not difficult to implement equivalent power selection in W because it is a normal function of the idle unit to scan through the frequencies while looking for increasing calls. The unit determines transmit power depending on the field strength on that channel determined in the previous two seconds.

Figure 4b shows a crude arrangement where the responding unit W simply receives a command from Y and adopts the power level of Y and Figure 4c illustrates mutual power control whereby each unit commands the other unit to reduce power until the received signal from at least one unit is below the predetermined threshold T_s.

A unit which has set up a call at reduced power is not allowed to increase power subsequently, even after the initial full power unit has stopped. It can therefore be envisaged that another unit can start on full power even though it is close to a pair operating at low power. This situation is illustrated in Figure 5 in which typical field strength values have been substituted by way of example as follows: Max = +10dBm, T_s = −40dBm, Tu = −65dBm and T_L = −85dBm. U and V are initally in communication at P_T = −10dBm and Y wishes to set up a call on the channel. U and V have undergone mutual power control until Rs for at least one unit is −40dBm (T_s). More specifically, the procedure is that if in the first 200ms of handshake exchange the received signal levels of both units exceed −40dBm, then the power of both units is reduced in 10dB steps until only one unit exceeds −40dBm. This reduced power is then held constant for the remainder of the contact. Y is now free to set up the call at full power because the field strength of the existing call at Y is −85dBm. However, this illustrates the need for quite a high choice of T_s as otherwise the new call might interfere with the call already in existence.

In this numerical example, suitable power reduction steps might be 10dBm so that for:

Rs ≤ −85dBm, P_T = +10dBm Rs ≤ −75dBm, P_T =0dBm Rs ≤ −65dBm, P_T = −10dBm Rs > −65, P_T = zero

It will of course be understood that the present invention has been described above purely by way of example, and modifications of detail can be made within the scope and spirit of the invention.

CLAIMS

1. A communications device comprising a radio receiver and a radio transmitter and means for automatically reducing the transmit power on a communications channel below maximum in response to the received signal level of existing users on that channel so as to reduce the likelihood of interference to the existing users.

2. A device according to claim 1 which comprises means for reducing the transmit power by an amount dependent on the amount by which the said received signal level exceeds a predetermined lower threshold.

3. A device according to claim 1 or 2 further comprising means for comparing said received signal level with a higher threshold and inhibiting communication if the said signal level exceeds the higher threshold.

4. A device according to any one of the previous claims comprising means for searching through radio channels, measuring the signal strength of existing users on the channels and selecting the channel on which the said signal strength is least, before commencing transmission on that channel.

5. A device according to any one of the previous claims comprising means for reducing the transmission power in incremental steps.

6. A communications device (the first device) according to any one of the previous claims for communicating with a second such device wherein means is provided for transmitting to the second device an encoded command for controlling the transmit power of said second device and means is provided for receiving and decoding an encoded command from the said second device for controlling the transmit power of the first device.

7. A device according to claim 6 wherien means is provided for adopting a transmit power which is the lower of the two transmit powers of the first and second devices.

8. A device according to claim 7 or 8 wherein means is provided for commanding the second device to reduce power until the signal received from that second device falls below a predetermined field strength as received by the first device.

9. A device according to any one of claims 6, 7 or 8 wherein means is provided for scanning the communications channels when waiting for a communication link to be initiated, for measuring the field strengths on those channels, for storing those field strengths and for adopting a transmit power which is dependent on a field strength at an earlier instant as stored.

10. A device according to any one of the previous claims which is a handset of a cordless telephone.

11. A device according to any one of the previous claims which is a base unit of a cordless telephone.

12. A method of occupying a channel in an interactive communication device comprising the steps of measuring the radiation strength on that channel and occupying the channel at a transmit power which is reduced from maximum by an amount dependent on the measured radiation strength.

13. A device substantially as hereinbefore described with reference to the accompanying drawings.

14. A method of occupying a channel in an interactive communication device substantially as hereinbefore described with reference to the accompanying drawings.

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